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ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Engelmann Spruce Seed Dispersal and Seedling Establishment in Clearcut Forest Openings in Colorado — *a progress report*

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Results through the summer of 1967 are reported from five locations for periods up to 6 years. Good crops of 100,000 or more seeds per acre were produced only once in 4 or 5 years on three areas; elsewhere seed crops were good in 2 of 6 years. Seedfall into clearcut openings decreased rapidly beyond about 1.5 chains from standing timber, but considerable sound seed was still dispersed across openings in years of good seed production. In general, openings were stocked with less than 300 well-distributed trees per acre; seedling establishment appeared to be limited more by environmental factors that affect germination and survival than by seed supply.

Seedling survival and seed production data are needed to estimate the amount of seed required for natural regeneration success under different conditions. Seed dispersal distances determine the size of clearcut opening that will adequately restock. Since Engelmann spruce (Picea engelmannii Parry)—subalpine fir (Abies lasiocarpa (Hook.) Nutt.) forests grow under a wide range of environmental conditions, information obtained on seedfall and seedling survival in one area may not be applicable elsewhere. Consequently, studies were started in 1961 at five locations in the spruce-fir type in Colorado to determine the amount and frequency of seed crops, seed dispersal in relation to distance from source, and initial seedling survival. This Note summarizes the results through 1967.

Study Areas and Methods

Study areas were established in clearcuts on the Arapaho, Rio Grande, Routt, San Juan, and

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White River National Forests (table 1). Cutover areas, except on the White River, were selected with the long axis of the cutting unit oriented at right angles to prevailing westerly and southwesterly winds. Since topography on the White River appeared to alter the prevailing wind direction, the cutover unit selected was oriented with respect to local winds.

Merchantable trees (10.0 inches d.b.h. and larger) on the areas were logged. Residual trees, including snags, that were large enough to provide an internal seed source or create eddy currents and obstructions in the glide path of seeds from surrounding timber stands were felled before seed traps were installed.

Quantity of seed produced and dispersal distances were measured with 1-foot-square wire seed traps described by Boe.[2] Traps were placed 0.5 chain apart in rows parallel to the long axis of the clearcut (fig. 1). Each row contained 10 traps, but the number of rows on each Forest varied with the width of the cutover (table 1). Trap installation and location with reference to timber edges were similar on each Forest.

Traps were initially installed only in the area logged, but in the summer of 1964 a row of 10 traps was placed 1 chain into uncut stands on the windward and leeward sides of openings.

Annual seed count data were summarized through the summer of 1967, except on the Rio Grande National Forest where collections were discontinued after 1965. Seedfall was recorded in uncut stands only in 1965 and 1966, but not enough seed was caught in either year to make reliable estimates of seed production. In other years, estimates of seed production were based on the amount of seedfall at the edge of the clearcut openings.

Seedling survival was recorded on 1/300-acre circular plots established at each seed trap location within the cutover area (fig. 1). On three of the Forests—Arapaho, Rio Grande, and White River—

[2] *Boe, K. N. A one-foot-square wire seed trap. J. Forest. 53: 368-369. 1955.*

Table 1.--Description of Engelmann spruce seed dispersal and seedling establishment study areas on five National Forests in Colorado

National Forest and Ranger District	Drainage	Elevation	Year logged	Year study established	Size of cutover	Aspect	Slope	Rows of traps[1]
		Feet					Percent	Number
Arapaho								
Hot Sulfur	Stillwater Creek	10,400	1958	1961	2-chain contour strip	N70E	33	4
Rio Grande								
Saguache	California Gulch	10,800	1959	1961	4-chain contour strip	N70E	15	6
Routt								
Bears Ears	West Prong, South Fork Slater Creek	9,400	1961	1963	26-acre block	S37W	16	10
San Juan								
Dolores	Spring Creek (on Taylor Mesa)	10,200	1959	1962	32-acre block	N38E	5	15
White River								
Frying Pan	Rocky Fork Creek	11,100	1956	1961	4-chain contour strip	N20W	20	6

[1] Includes rows placed beneath uncut stands on the leeward and windward sides of openings.

logging slash was removed manually from the plots with little disturbance of the seedbed. Plots were scarified to some extent, however, in logging. On the Routt and San Juan study areas, where logging slash was piled with a tractor-mounted rake and burned, plots were heavily scarified.

All seedlings left on plots immediately after logging were removed, and only those seedlings that germinated after the study began were counted. New seedlings were identified with plastic markers showing year of germination.

Results

Seed Dispersal

Engelmann spruce seed production varied by year and location. Good seed crops—100,000 or more sound seeds per acre—were most frequent on the Arapaho (1961 and 1963) and White River (1963 and 1964). Good crops were also produced on the Rio Grande and Routt in 1964, and on the San Juan in 1963. Moderate crops—50,000 to 100,000 sound seeds per acre—were produced on the Arapaho in 1964 and on the White River in 1961. In other years of observation, seed crops were poor to complete failures. Total seedfall into openings, and seedfall during individual years of moderate to good seed production, are shown for all Forests in figure 2.

In most years when seed was produced in significant amounts, seedfall was similar on all Forests. Seed dispersal into openings decreased as distance from source increased. Most seeds fell within 1.5 chains of standing timber.

Prevailing winds apparently influenced the pattern of seedfall on most Forests in years of significant production. Seedfall was greatest near the windward side of the openings, and diminished

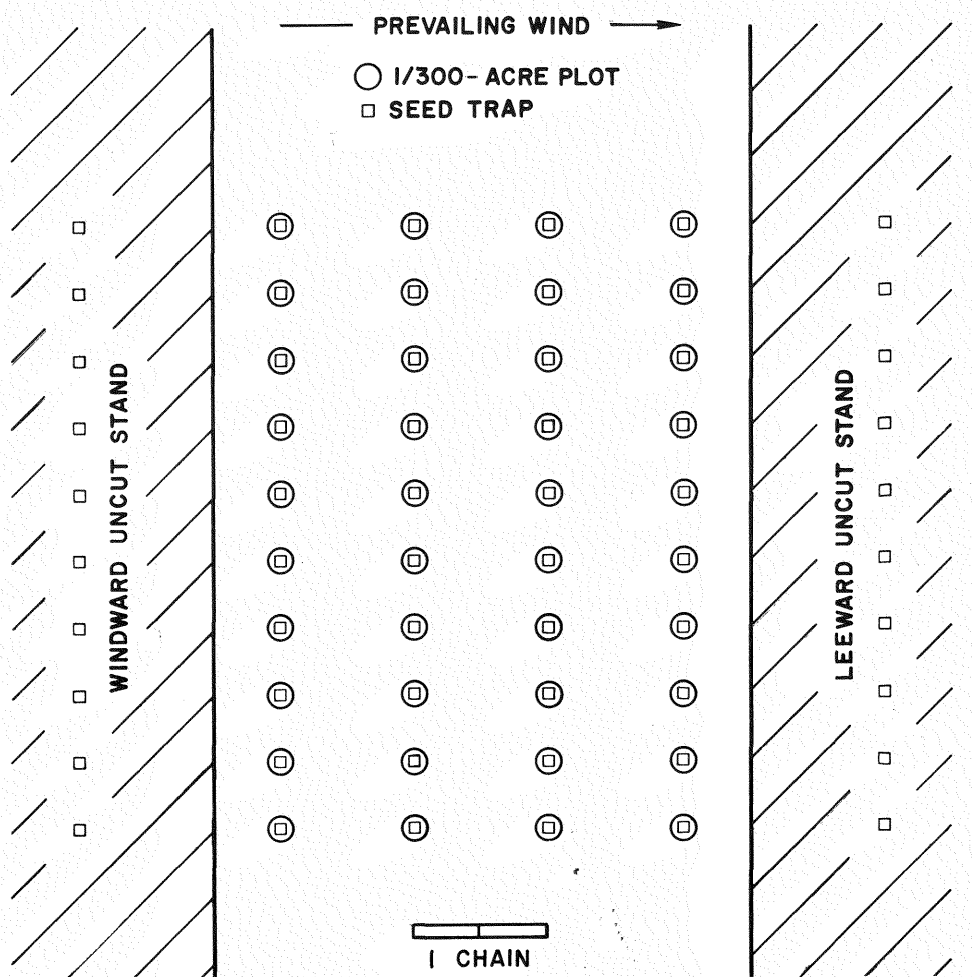

Figure 1.-- Location of seed traps and seedling survival plots (1/300 acre) within a clearcut contour strip on the Rio Grande National Forest; study areas on other Forests were similar except for width of cutover opening.

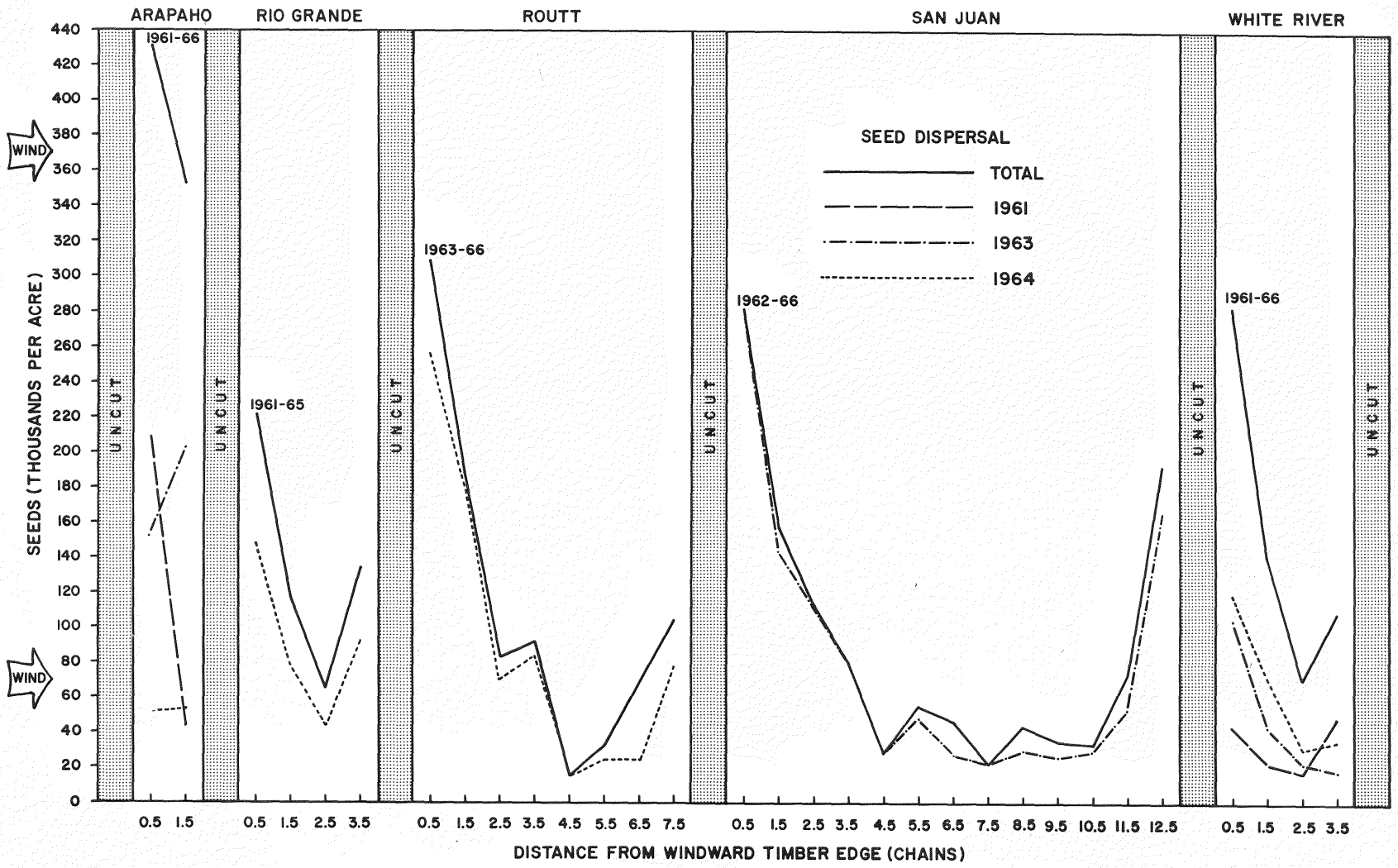

Figure 2.--Seed dispersal by distance from windward edge of clearcut openings on five National Forests for moderate to good seed years (1961, 1963, 1964), and total for all years measured on each Forest.

steadily as distance increased to about 1/2 to 2/3 of the way across the openings, where the fewest seeds were caught—about 20 percent of the seedfall near the windward edge. The influence of wind direction on dispersal patterns was variable in years of poor seed production, and in the smallest openings (Arapaho) regardless of the quantity of seed produced.

Survival of Seedlings

Number and stocking of seedlings in 1967 was related to quantity of seedfall, distance from seed source, and seedling age (fig. 3). Most seedlings were found within 1.5 chains from seed source, but no relationship could be established between number of seedlings and location with respect to prevailing winds. More seedlings were alive near the windward timber edge on the White River and Routt, but on the San Juan and Rio Grande more live seedlings were found nearest the leeward timber stand.

Percentage of stocked 1/300-acre plots, shown in parentheses in figure 3, was also highest within 1.5 chains of standing timber, where seedlings were most abundant. Plots beyond about 1.5 chains were either poorly stocked or nonstocked.

Living seedlings were found on all Forests, but not all potential age classes were present on each Forest. The proportion of the total number of live seedlings within any age class also varied between Forests. In general, 2-year-old seedlings were most numerous and were found on all Forests. Fewer seedlings were recorded in the 3-year age class, but they were present on all Forests except the Arapaho. No 4-year-old seedlings were found, and only a few 5-year-old and 1-year-old trees were alive.

Survival of seedlings of all ages was poor on each Forest (table 2). Seedling mortality, which

Table 2.--Percentage survival of seedlings over all age classes at different distances from the windward edge of clearcut openings on five National Forests

Distance from windward edge of clearcuts (chains)	Survival by National Forest				
	Arapaho	Rio Grande	Routt	San Juan	White River
			Percent		
0.5	15	5	47	50	44
1.5	12	6	29	28	46
2.5	--	4	29	14	38
3.5	--	12	33	7	20
4.5	--	--	32	5	--
5.5	--	--	27	0	--
6.5	--	--	21	60	--
7.5	--	--	9	0	--
8.5	--	--	--	12	--
9.5	--	--	--	33	--
10.5	--	--	--	0	--
11.5	--	--	--	50	--
12.5	--	--	--	67	--

Note: "--" indicates not applicable.

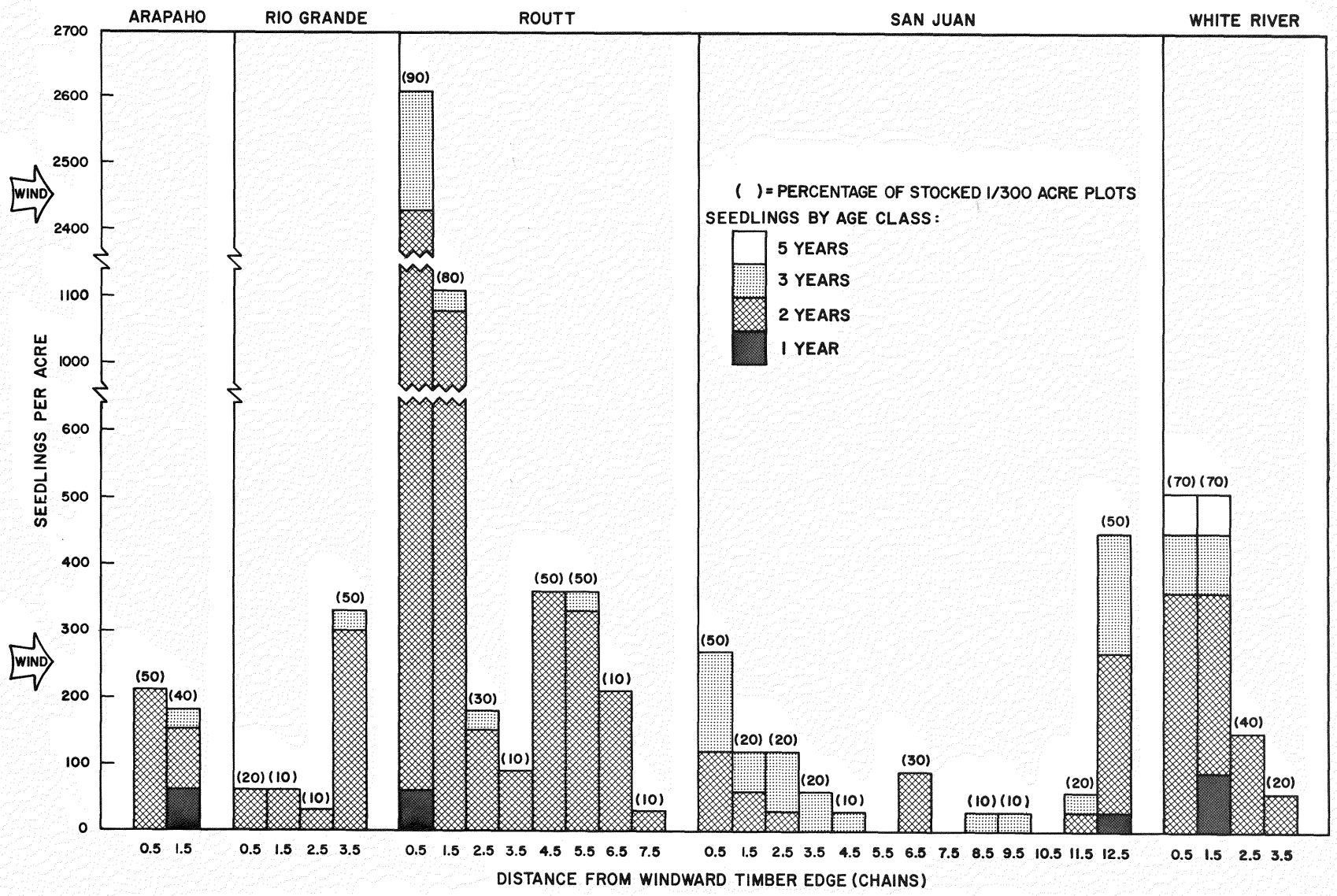

Figure 3.--Number of seedlings by age classes and percentage of stocked 1/300-acre plots (figures in parentheses) at different distances from the windward edge of clearcut openings on five National Forests. (Maximum possible age of seedlings: 5 years, Arapaho, Rio Grande, White River; 4 years, San Juan; 3 years, Routt.)

was highest in the 1-year age class, decreased as seedlings became older, but even 5-year-old seedlings died.

Discussion and Conclusions

Seed was produced each year on all study areas, but in most years the quantity was negligible. Furthermore, good crops did not occur the same year on all areas. Good crops were produced only once in 4 or 5 years on the Rio Grande, Routt, and San Juan National Forests. On the Arapaho and White River, however, good crops were produced in 2 of 6 years. Exceptionally good seed crops (1 million or more seeds per acre) as reported by Roe[3] in Montana were not recorded in Colorado during the period of observation; the last such seed year observed in Colorado was 1952.

Even though seedfall decreased rapidly beyond about 1.5 chains from standing timber, considerable sound seed was still dispersed across openings in years of good seed production. Roe[3] and Squillace[4] found that large numbers of sound seed were dispersed greater distances (7 to 10 chains) than reported here. They presented results from exceptional seed crops, however, and indicated that dispersal distances were not as great in years of lower seed production.

While seed in significant amounts fell into the openings beyond 1.5 chains, few seedlings became established beyond the margins of the openings. Regeneration success in the cutovers thus appeared to be limited more by adverse environmental factors than by seed supply. Exposure of seedlings to high light intensity and high temperatures, drying winds, and low temperatures and frost heaving contributed substantially to the poor survival in the openings.

Even near the margins of standing timber, where 300 or more seedlings per acre were alive, adequacy of regeneration is questionable because of the high mortality rate of young seedlings. Furthermore, the age at which those young seedlings can be considered to have a reasonable chance for survival cannot be determined now because losses have continued.

No recommendations can yet be made concerning the size opening that will restock to natural regeneration, the number of sound seeds needed to produce an established seedling, or total seed production required to adequately restock an area. Continuation of the study will provide information on seedling survival and establishment—including the age at which seedlings can be considered established—as well as additional data on the amount of seed produced, dispersal distances, and periodicity of seed crops.

[3]*Roe, Arthur L. Seed dispersal in a bumper spruce seed year. U.S. Forest Serv. Res. Pap. INT-39, 10 p. 1967. Intermt. Forest and Range Exp. Sta., Ogden, Utah.*

[4]*Squillace, A. E. Engelmann spruce seed dispersal into a clear-cut area. U.S. Dep. Agr. Forest Serv., Intermt. Forest and Range Exp. Sta. Res. Note 11, 4 p. 1954. (Ogden, Utah)*

Ronco, Frank. 1970.

Engelmann spruce seed dispersal and seedling establishment in clearcut forest openings in Colorado - a progress report. USDA Forest Serv. Res. Note RM-168.

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